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DEPARTMENT OF THE INTERIOR
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Doolittle, R.

WATERPOWER RESOURCES OF CALIFORNIA

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Supersedes report titled Gross Theoretical Waterpower, Developed & Undeveloped, State of California, released to open file by press release dated June 15, 1964.

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(This report supersedes the report titled "Gross Theoretical Waterpower, Developed and Undeveloped, State of California" by R. N. Doolittle, and K. W. Sax, released to open file by press release, dated June 15, 1964).

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WATERPOWER RESOURCES OF CALIFORNIA

Introduction

The 11,691 MW (1,000 kilowatts) of gross theoretical waterpower from its developed and undeveloped sites place California third among the States in the extent of this resource. This amount represents about 10 percent of the total in the United States and is exceeded only by the potential waterpower in Washington and Alaska.

California leads the Nation, however, in the production and consumption of electric energy. The total generating capacity, installed or planned for installation in plants under construction and scheduled for completion by December 1968, is approximately 26,500 MW, of which 6,688 MW, or 25 percent, is in 167 hydroelectric plants with capacities in excess of 100 kilowatts. About 79 billion kilowatthours of electric energy are consumed annually in California--approximately 30 percent is presently generated at hydroelectric plants--and the consumption of electric energy is increasing. In comparison, the United States has about 210,000 MW of installed generating capacity, with about 40,000 MW in hydroelectric plants. The national annual consumption of electric energy is about 950 billion kilowatthours, with about 18 percent produced at waterpower plants.

The installed capacity at hydroelectric plants in California has increased about 1,880 MW during the past 3 years. The increase is the result of an accelerated construction program by public and private developers. Federal development of power on the Trinity River, State construction of the Oroville and Thermalito plants on the Feather River, and Pacific Gas and Electric Company developments on the McCloud and Pit Rivers account for most of this increase. Only the State of Washington, with about 12,500 MW, exceeds California in installed hydroelectric generating capacity.

Gross Theoretical Waterpower

The U.S. Geological Survey maintains a current inventory of both developed and undeveloped waterpower and storage sites in the United States as part of its responsibility for classification of the public lands as to their mineral and power values. Dam and reservoir sites on the public lands are identified and classified to ensure consideration of this potential use. Evaluation of the waterpower resources of California, as a part of the power inventory, provides an index of the pattern of existing hydroelectric production and of the potential for future development. The inventory includes all developed sites with an installed capacity of 100 kilowatts or more and all undeveloped sites with a minimum theoretical potential of 1,000 kilowatts with gross head and the flow available 50 percent of the time (Q50). This procedure conforms to the latest standards of the World Power Conference (1962) which defines an "undeveloped site" as one having "such gradient, flow, and physical conditions that its development for the production of power may reasonably be assumed to be eventually practicable." This definition leaves considerable latitude in the selection of sites but provides for a sound estimate of "gross potential."

The "gross theoretical power" of a powersite is considered to be the full potential output at 100-percent efficiency. When the head "h" is in feet, and the flow "Q" is in cubic feet per second, the gross theoretical power expressed in kilowatts is 0.085Qh. The determinations of gross theoretical power are made for three different rates of flow, namely: The flow available 95 percent of the time (Q95), the flow available 50 percent of the time (Q50), and arithmetical mean flow (Qm). The "gross head," used in the computations, is the difference in elevation between the water surface at the point of diversion and that at the point of return, without reduction for losses, at the time of such flows.

The potential power, based on mean flow (Qm), represents the maximum attainable. This condition could be realized only if sufficient storage were available to regulate the streamflow so that all the water would be utilized through the turbines. Such regulation is desirable, but is not attainable on many streams. Further, though estimates are based on 100-percent efficiency, experience has shown that overall efficiencies for power projects vary between 75 and 85 percent.

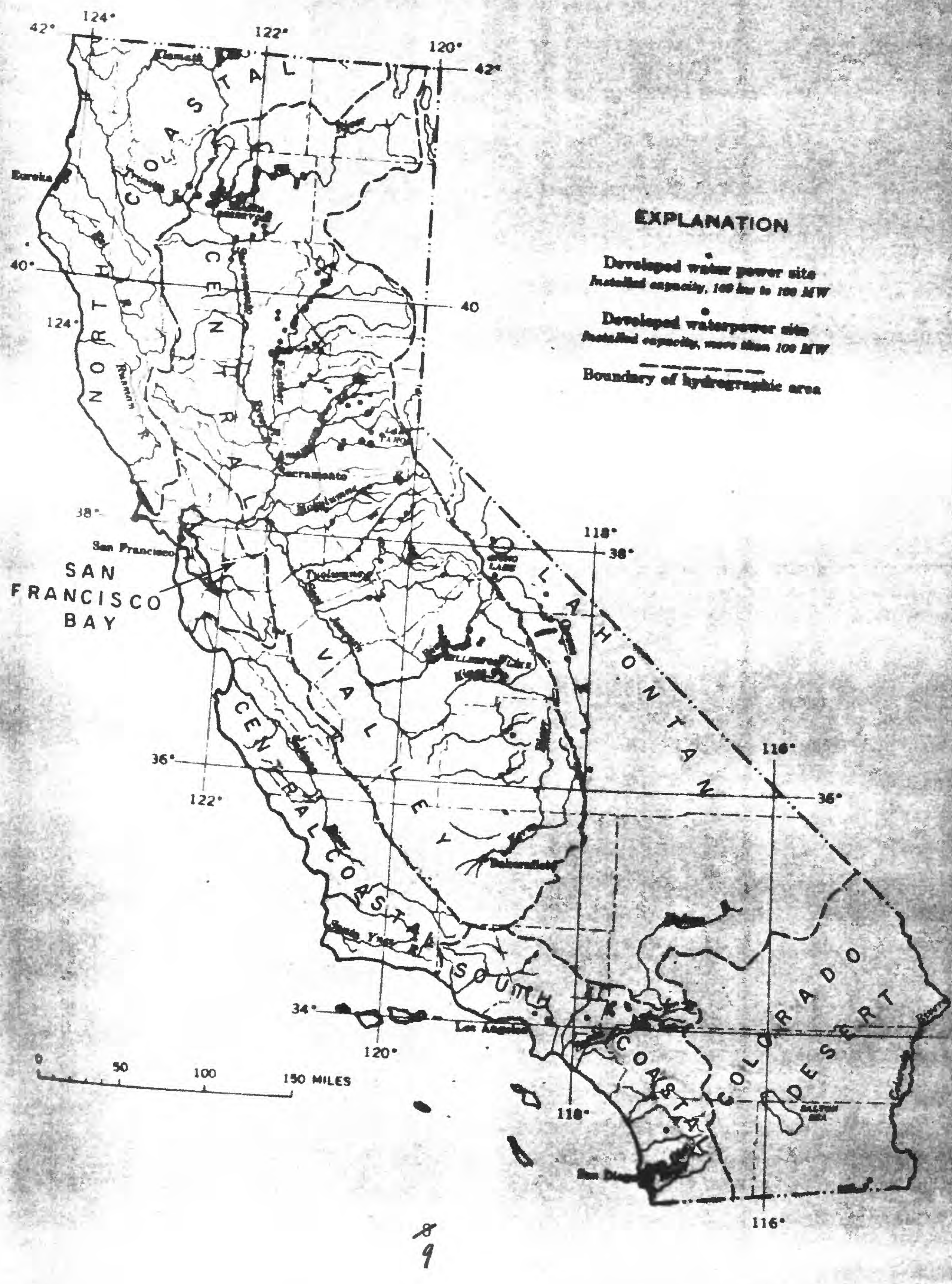
A summary of the data on size and distribution of developed powersites is shown in table 1 and details of individual sites are shown in table 3. The location of these plants and the hydrographic-area boundaries are shown in figure 1. The 21 largest plants, representing one-eighth of the total number in the State, include nearly 53 percent of the total installed capacity.

Table 1.--Summary of size and distribution of developed waterpower sites in California

Installed capacity (MW)	North Coastal Area		South Coastal Area		Central Valley Area		Lahontan Area		Colorado Desert Area		Totals			
	No. of sites	Total installed capacity (MW)	No. of sites	Total installed capacity (MW)	No. of sites	Total installed capacity (MW)	No. of sites	Total installed capacity (MW)	No. of sites	Total installed capacity (MW)	No. of sites	Percent of total	Installed capacity (MW)	Percent of total
Less than 10	5	15.8	18	25.4	39	176.9	13	51.4	2	11.4	77	46	280.9	4
10-25	2	38.0	-	-	20	313.3	1	10.0	2	29.6	25	15	390.9	6
25-50	1	27.0	1	42.0	13	450.5	3	112.5	1	33.0	19	11	665.0	10
50-100	-	-	1	58.1	23	1,647.8	-	-	-	-	24	15	1,705.9	25
More than 100	1	100.00	-	-	20	3,425.3	-	-	1	120.0	22	13	3,645.3	55
Totals	9	180.8	20	125.5	115	6,013.8	17	173.9	6	194.0	167	100	6,688.0	100
Percent of total	5.4	2.7	12.0	1.9	68.8	89.9	10.2	2.6	3.6	2.9	-	-	-	-

MW = Megawatt (1000 kilowatts)

FIGURE 1



EXPLANATION
Developed water power site
Installed capacity, 100 kw to 100 MW
Developed waterpower site
Installed capacity, more than 100 MW
Boundary of hydrographic area
NORTH COASTAL
CENTRAL VALLEY
LAHONTAN
SAN FRANCISCO BAY
CENTRAL COASTAL
SOUTH COASTAL
COLORADO DESERT
Eureka
San Francisco
Sacramento
Los Angeles
Bakersfield
0 50 100 150 MILES

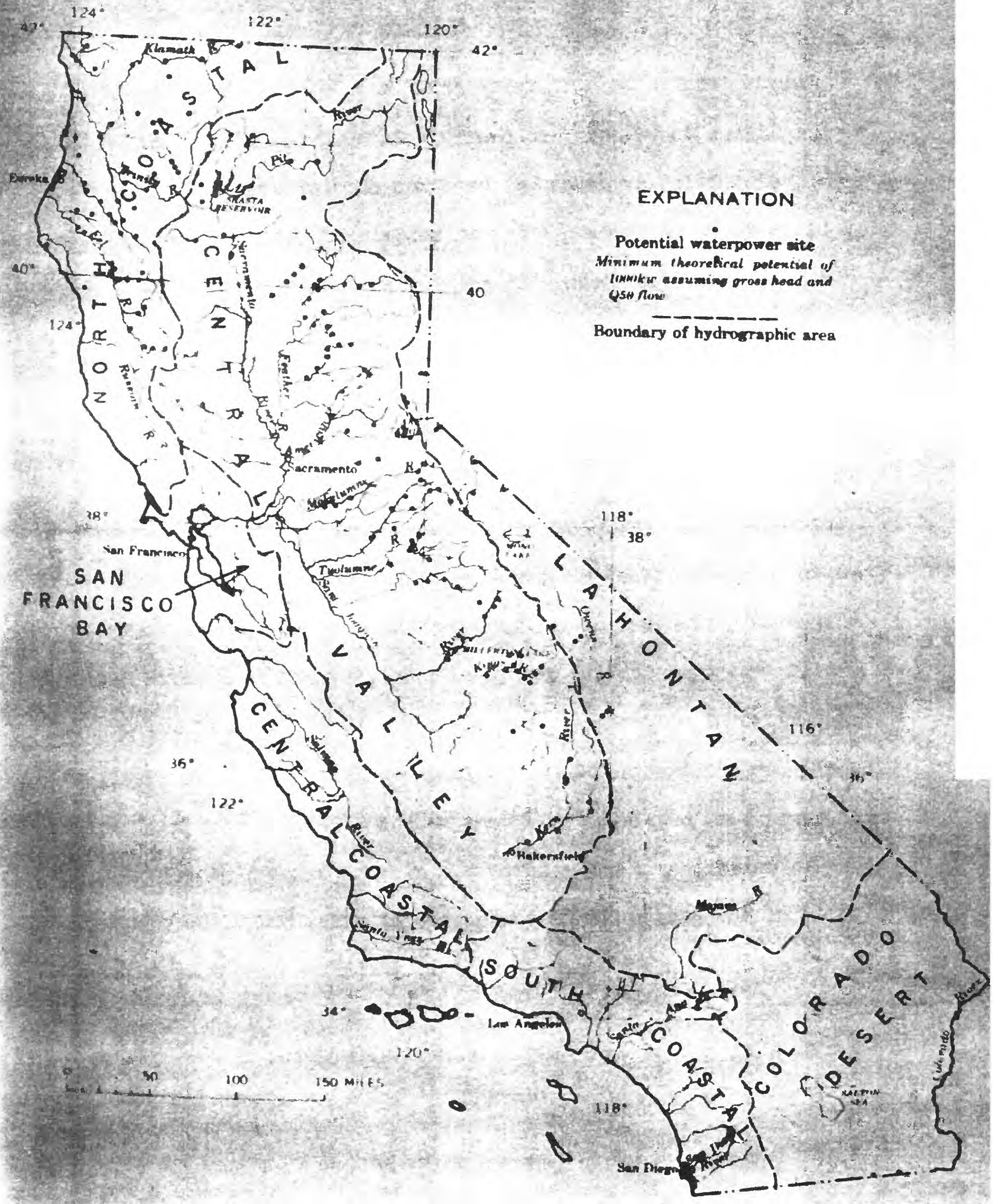
The gross power theoretically capable of being developed at both developed and undeveloped sites is summarized in table 2; it is classified according to hydrographic-area location and capacity at the Q95, Q50, and Qm flows. Details of individual undeveloped sites are shown in table 4. The location of the undeveloped powersites is shown in figure 2. Gross theoretical power, as shown at developed sites, is an indication of potential only and does not imply economic feasibility of development. Pumped-storage plants are not included in the discussion of waterpower as a resource, because such plants consume more power then they produce. In a like manner, the power proposed for development by the State in run-of-the-aqueduct plants is not included.

Table 2.--Summary of gross theoretical potential at developed and undeveloped waterpower sites in California

Hydrographic area	Developed waterpower sites: No. of sites	Developed: Gross theoretical power (MW), gross head (100% efficiency), flows at-- Q95	Q50	Qmean	Installed capacity (MW)	Undeveloped waterpower sites: No. of sites	Undeveloped: Gross theoretical power (MW), gross head (100% efficiency), flows at-- Q95	Q50	Qmean	Total gross theoretical power (MW), developed and undeveloped sites based on mean flow
North Coastal Area	9	21.7	101.7	152.3	180.8	55	379.3	1,519.9	3,018.6	3,170.9
South Coastal Area	20	40.5	76.9	93.0	125.5	4	5.3	9.4	16.1	109.1
Central Valley Area	115	1,277.6	3,011.1	5,094.2	6,013.8	90	373.8	1,206.5	2,965.9	8,060.1
Lahontan Area	17	48.1	95.8	129.7	173.9	12	11.4	31.8	80.9	210.6
Colorado Desert Area	6	54.6	123.9	129.8	194.0	2	5.2	9.3	10.3	140.1
Total	167	1,442.5	3,409.4	5,599.0	6,688.0	163	775.0	2,776.9	6,091.8	11,690.8

MW = Megawatt (1000 kilowatts)

FIGURE 2


EXPLANATION
Potential waterpower site
Boundary of hydrographic area
NORTH COASTAL
CENTRAL VALLEY
LAHONTAN
CENTRAL COASTAL
SOUTH COASTAL
COLORADO DESERT
SAN FRANCISCO BAY
Eureka
San Francisco
Sacramento
Bakersfield
Los Angeles
San Diego
Klamath R.
Tuolumne
0
50
100
150 MILES

History

The site and time of the first generation of hydroelectric power in California is uncertain. There are reports of small direct-current plants in both northern and southern California furnishing electricity, mainly for street lighting, as early as 1887, but inadequate transmission facilities prevented further expansion.

The Pomona plant of the San Antonio Light and Power Company, which commenced operation late in 1892, was the first alternating-current station in California. Electricity generated at 1,000 volts was stepped up to 10,000 volts and transmitted 14 miles to the city of Pomona, where voltage was reduced to usable levels. It was the first successful application of this principle in the United States.

Construction of the Folsom powerhouse, on the left bank of the American River near the town of Folsom, was another important milestone in the history of hydroelectric power generation in California. This plant, with an installed capacity of 3,000 kilowatts, was placed in operation July 13, 1895, and at that time developed more power than any other electric powerplant in the world. The transmission of electricity at 11,000 volts to Sacramento 22 miles away did much to demonstrate the practicability of long-distance transmission at high voltage.

The next 15 years represent a period of rapid expansion in California's hydroelectric power industry with more than 50 plants being placed in operation. Although these plants were located from the Klamath River on the northern border to the San Bernardino Mountains in the south, most of the growth occurred north of the Tehachapi Mountains. Today 115, or two-thirds, of California's 167 hydroelectric plants, developed or under construction are in the Central Valley; and their combined installed hydropower capacity is about 90 percent of the total in the State.

Northern California owes its preeminence in hydroelectric capability primarily to the factors of topography and the availability of water. Nature provided the vital concentrations of head in the rapidly falling streams of the Sierra Nevada, but the gold miners left the heritage of legal rights to water sources and a vast network of artificial watercourses. Long before scientists had learned to produce electricity for light and other power purposes, the shovel, pan, and rocker method of gold extraction had given way to the flume and sluice box, making a constant flow of water a major requirement for successful mining. With the advent of hydraulic mining, a vast network of flumes and ditches began to develop. Reportedly, by 1863 approximately 5,000 miles of such waterways had been developed, and by the early 1900's the system had grown to about 8,000 miles. During this period a millwright, Lester Allen Pelton, had developed the Pelton wheel, a much more efficient device than the overshot wheel which had been used for years to power mechanical equipment. When the Federal courts forced an end to hydraulic mining because of the debris problem, the water systems and the Pelton wheel, which is still used in many power-plants, were available for use by the developers of hydroelectric power.

Ownership

Ownership of the State's hydroelectric-power facilities is widely distributed with nearly all phases of the electric-utility industry being represented. Three major investor-owned public utilities are operating hydroelectric generating plants in the State. The Pacific Power and Light Company, successor to the California Oregon Power Company, has developed four plants on the Klamath River with a combined installed capacity of 67.2 MW. The Pacific Gas and Electric Company, started in Nevada County in 1850 as the Rock Creek Ditch Company, is the largest producer and distributor of hydropower in California. Its plants dot the Central Valley from the Pit River in the north to the Kern River in the south. The system includes 64 hydroelectric plants with an installed capacity of 2,074 MW. The Pacific Gas and Electric Company system also includes 14 steam-electric plants with a capacity of 5,447 MW. The Southern California Edison Company has 717 MW of installed hydro capacity in 35 California plants. About 593 MW of this is concentrated in eight San Joaquin River plants.

Seven plants on Bishop Creek contain 44 MW of installed generating capacity. The remaining 20 plants, with 80 MW of installed capacity, make up the company's Southern Hydro Division, which extends from the Mono Lake basin on the north to the city of San Bernardino on the south. The company also operates 12 steam plants in California with an installed capacity of 5,553 MW.

The U. S. Bureau of Reclamation, with 1,014 MW of installed capacity at plants in its Central Valley Project and 120 MW at Parker powerhouse on the Colorado River is, with one exception, the only Federal agency engaged in the generation of power in the State. The National Park Service, for its own use, generates electricity at a 2,000-kilowatt hydroplant on the Merced River, within Yosemite National Park.

The cities of Los Angeles, San Francisco, Sacramento, and Oakland are all engaged in the generation of hydropower. All four cities obtain part of their municipal water supply from Sierra Nevada streams or from sources at much higher elevations than the place of use. All have found it profitable to utilize these large flows and considerable heads in the generation of electricity for which there is a ready market. Sacramento, through the Sacramento Municipal Utility District, has power rights only to water of the Middle and South Forks American River and is rapidly expanding its hydrogeneration and distribution systems to fully utilize these rights.

Many irrigation districts and county water agencies have built and are building complex water-development projects which depend upon waterpower revenues for their economic feasibility. Water rights for these projects, which combine irrigation, flood control, and recreation with the generation of hydropower, are usually obtained through the assignment of early State prescriptions to the counties of origin. The Turlock-Modesto Irrigation Districts combined to pioneer the first of such projects in conjunction with irrigation use of Tuolumne River water. Rising costs, the intense competition for water, and the technological development in steam-electric generation, have almost eliminated single-purpose projects.

Areal Distribution of Waterpower

Appraisal of the extent of the waterpower resources of California is facilitated by consideration of the distribution of developed and undeveloped sites within the principal hydrographic areas of the State. The hydrographic areas are delineated on figures 1 and 2, which show the location of developed and undeveloped sites respectively.

The San Francisco Bay and Central Coastal Areas have no significant potential for waterpower development and no installations with capacity greater than 100 kilowatts.

North Coastal Area

The rugged, snow-capped terrain of the Cascade and Klamath Mountains and the less rugged Coast Ranges, which intercept the moisture-laden winds from the Pacific Ocean, provide the flow and fall essential to hydropower generation. The first two ranges are ideal in that the heavy snowpack serves as a natural reservoir, sustaining flows well into the summer months. The Coast Ranges, however, permit prompt runoff from the 15 to 100 inches of rainfall each year, and artificial storage is essential for any significant hydroelectric power development.

The North Coastal Area, from which about 41 percent of California's surface water drains to the ocean, has less than 3 percent of the State's installed hydroelectric capacity. However, nearly half of the State's undeveloped water potential is in the North-Coastal rivers.

The Trinity and Lewiston plants of the U. S. Bureau of Reclamation, with a total installed capacity of 100.3 MW, develop more than half the hydroelectric power generated in the North Coastal Area. These plants, on the upper Trinity River, are elements of the Bureau's Central Valley Project. All, except 4 MW of the remaining generating capacity of the area is concentrated in four plants of the COPCO Division of the Pacific Power and Light Company on the upper Klamath River, above its confluence with the Shasta River. A legal restriction, in effect since 1924, prevents construction or maintenance of dams on the Klamath River below this point.

Lack of industrial development to provide a market for power and an abundance of water to satisfy limited agricultural and domestic need have limited water-resource development in general and, consequently, hydroelectric power production, which lends itself well to multiple-use development but is seldom justified for single use. The recreation and timber industries are expanding in the Humboldt Bay region and, as resulting villages develop along the river bottoms, the need for flood control increases. This fact was emphasized recently by the extremely heavy damage caused by floods in the lower Eel and Klamath River basins. The need, coupled with the growth of statewide water demands, has led to a State-Federal interagency study of plans for developing the water resources of northwestern California. Major water-control and conservation projects constitute the principal elements of a multiple-purpose plan.

With complete development of power potential, the area could produce about 1,500 MW of power with flows available 50 percent of the time and 3,000 MW with mean flows. Diversions of water from the North Coastal Area to the Central Valley Area will materially reduce the gross theoretical power potential of the area. In addition, large blocks of power will be consumed by the associated pumping operations.

South Coastal Area

Waterpower installations in the South Coastal Area are limited to a few small plants, constructed at about the turn of the century, in the San Gabriel and San Bernardino Mountains. The very limited water supply and heavy demands for irrigation and municipal supply preclude any significant increase in hydroelectric power development, except for that which may result from large importations of water. There are a few minor undeveloped sites in the San Bernardino Mountains.

Central Valley Area

The Central Valley Area, which comprises the Sacramento and San Joaquin River valleys, includes 38 percent of California's landmass and contributes about 47 percent of its average runoff. Within the area 115 developed waterpower sites account for about 90 percent of the State's installed hydroelectric generating capacity. Most of these plants are on the 10 major streams draining the Sierra Nevada, so, in effect, streams draining about 11 percent of the State's area have 67 percent of the State's installed generating capacity and about 50 percent of its gross theoretical hydropower potential, developed and undeveloped.

Upper Sacramento River basin

The upper Sacramento River system drains the Trinity and Cascade Mountains and receives diversions from the Trinity River. The system is quite thoroughly developed. The U. S. Bureau of Reclamation operates two plants along the Trinity River diversion route, as well as the Shasta and Keswick plants on the Sacramento River. The Pacific Gas and Electric Company has developed most of the sites on the Pit and McCloud Rivers and Cow, Battle, and Butte Creeks. Although there are about 15 undeveloped sites in the basin, the only remaining undeveloped head of major significance is on the Sacramento River below the Keswick powerhouse.

Feather River basin

The Feather River basin, which includes the Yuba and Bear Rivers, is presently the scene of great activity in the field of water-resource development, including the construction of hydroelectric powerplants. There are 30 plants existing or scheduled for completion by 1968. These plants will have an installed capacity of about 1,713 MW, of which some 759 MW will be in the Oroville and Thermalito Afterbay power developments of the California Department of Water Resources. The Pacific Gas and Electric Company's Big Bend No. 1 plant will be inundated by the Oroville reservoir so is excluded from this report.

The Pacific Gas and Electric Company operates, or has under construction, 23 hydroplants in the basin with a combined installed capacity of about 800 MW. The Nevada Irrigation District has two plants, totaling 60 MW, under construction on the Bear River. The Oroville-Wyandotte Irrigation District operates three plants with a total installed capacity of about 90 MW. The gross theoretical power potential at undeveloped sites in the basin is about 300 MW with Q50 flows and 780 MW with mean flows, the latter representing complete regulation.

American River basin

The Pacific Gas and Electric Company commenced generation of hydropower in 1903 at its American River plant on the South Fork American River. This plant was abandoned recently as a result of developments on the South Fork American River by the Sacramento Municipal Utility District. At the present time the company operates only two small plants on the river.

Optimum development of the waterpower resources of the American River, however, is rapidly approaching reality. The U. S. Bureau of Reclamation presently operates the Folsom and Nimbus hydroelectric plants as part of the Central Valley Project. The Auburn-Folsom South Unit of this project which includes a 2,500,000-acre-foot Auburn reservoir and 240 MW powerplant on the North Fork American River was recently authorized by Congress, and early construction is anticipated.

The Placer County Water Agency has an extensive hydroelectric development under construction on the Middle Fork American River including four hydroplants with a combined installed capacity of 210 MW.

The Sacramento Municipal Utility District has recently constructed five hydroelectric plants and has one under construction on the South Fork American River. They are also investigating the Loon Lake powersite on Gerle Creek, tributary to the Middle Fork American River.

The North Fork canyon, which at one point is 3,500 feet deep, is the major undeveloped part of the basin. There is little opportunity for storage in this rugged canyon, and there has been general agreement that the area might best be left in its present state for recreation purposes.

Mokelumne River basin

The hydroelectric power potential of the Mokelumne River, which is the principal source of water supply for the metropolitan area served by the East Bay Municipal Utility District, has been substantially developed by the district and by the Pacific Gas and Electric Company. The district operates a 15-MW plant in conjunction with Pardee reservoir, one of its two major storage reservoirs. Pacific Gas and Electric Company, which purchases the power generated at Pardee powerplant, operates five plants within the basin with a total installed capacity of about 193 MW.

Stanislaus River basin

This San Joaquin River tributary has nine developed hydroelectric powersites with a total installed capacity of 200 MW. Eight undeveloped sites in the basin have a potential capacity of about the same magnitude. The Utica Mining Company built the Utica plant near Murphys in 1895. This plant, now called Murphys, and owned by Pacific Gas and Electric Company, was relocated a short distance upstream in 1898. Of the nine plants in the basin, six are owned by Pacific Gas and Electric Company and three by the Oakdale-South San Joaquin Irrigation Districts. New Melones reservoir with 2,400,000 acre-feet of storage and the 150-MW New Melones powerplant have been authorized for construction by the U. S. Army Corps of Engineers, and preliminary construction is scheduled to start in 1966. The U. S. Bureau of Reclamation will operate the powerplant as part of its Central Valley Project. Several other projects are under active investigation at the present time and continued development is assured.

Tuolumne River basin

The Raker Act of 1913 granted the city of San Francisco the right to develop the Hetch Hetchy Project in Yosemite National Park and Stanislaus National Forest. This project, which will ultimately provide some 400 million gallons per day of Tuolumne River water to the city, utilizes the fall from the high Sierra Nevada to generate hydropower in three plants having a combined installed capacity of 287 MW.

The Turlock and Modesto Irrigation Districts have combined forces to construct and operate the La Grange and Don Pedro hydroplants with installed capacities of 4.3 MW and 27 MW, respectively. The two districts, with the assistance of the city of San Francisco, which would benefit from exchange storage, and the Federal Government, which would benefit from flood-control storage, are actively planning a new Don Pedro reservoir and powerhouse. This reservoir would store more than 2,000,000 acre-feet of water, and a powerhouse at the dam would have an installed capacity of 131 MW.

About 100 MW of undeveloped hydropower may be available at several other sites in the basin.

Merced River basin

Much of the theoretical power potential of the Merced River lies within the boundaries of Yosemite National Park at sites such as Yosemite and Bridal Veil Falls. Development of any site within the park would require Congressional approval, and use of these sites probably would be considered as not in the public interest because of possible detriment to the scenic value.

The Pacific Gas and Electric Company and the National Park Service each have a small hydroplant on the river, but the Merced Irrigation District is the major developer of hydropower in the basin. The district has operated the Exchequer plant since 1926 in conjunction with the storage of irrigation water in Lake McClure; the output of the plant is sold to the Pacific Gas and Electric Company. A project is now underway to raise existing Exchequer Dam about 169 feet and increase the installed capacity at the new powerhouse to 80 MW. The McSwain afterbay dam and powerhouse will have an installed capacity of 9 MW. There are several potential sites upstream from the Exchequer plant and outside of Yosemite National Park; one of these, the Bagby site, originally had been proposed for development along with construction of Exchequer Dam, but later was deferred.

San Joaquin River basin

The San Joaquin River above Friant Dam might be considered as a separate basin in the same way as the Sacramento River above Keswick Dam. Hydroelectric-power facilities in this basin are divided between the Pacific Gas and Electric Company and the Southern California Edison Company. Pacific Gas and Electric Company operates 6 hydroelectric plants in the basin; 3 on Willow Creek, 1 at the forebay of the A. G. Wishon powerplant, and 2 on the main stem of the San Joaquin River. These plants, with an installed capacity of 72 MW, were constructed by the San Joaquin Light and Power Company between 1906 and 1920. The licenses for these projects were transferred to Pacific Gas and Electric Company on November 22, 1939.

The remainder of the plants on the upper San Joaquin River and its tributaries were constructed by the Southern California Edison Company, which describes its combined project as the "hardest working water in the world." Starting with Big Creek No. 1 and No. 2 plants in 1913 the system had grown to 8 plants in 1960, with an installed capacity of 593 MW.

Several undeveloped powersites are available above Mammoth Pool reservoir on the main stem of the San Joaquin River and on the North and Middle Forks. The Miller Bridge and Forks reservoir sites offer potential storage on the main stem, and several plans have been proposed for storage on and diversions from the North Fork San Joaquin River and Granite, Jackass, and Chiquito Creeks.

Kings River basin

For many years the great hydroelectric-power potential inherent in this rugged and untamed river was undeveloped, largely because of disputes over water rights. Irrigation demands precluded upstream storage so essential to power development on a river with highly irregular flows. Balch No. 1 plant was completed in 1927 by the San Joaquin Light and Power Company, predecessor of Pacific Gas and Electric Company, and was first limited to the use of natural flows of the Kings River. With the construction of Pine Flat Dam in 1954 by the U. S. Army Corps of Engineers it became possible to develop upstream power storage, as

Pine Flat reservoir provided reregulation of power flows for irrigation as well as for flood control. Courtright and Wishon Dams and reservoirs were developed on the North Fork Kings River by the Pacific Gas and Electric Company to provide storage for Haas and Blach No. 1 and No. 2 plants on the North Fork and the Kings River plant at the upper end of Pine Flat reservoir. These four plants have an installed capacity of 307 MW.

The undeveloped gross potential remaining is about 480 MW with mean flows and 165 MW with flows available 50 percent of the time. This potential includes the Tehipite Valley and Cedar Grove sites that involve highly controversial storage in Cedar Grove and Tehipite Valley, both of which areas have competitive recreational and scenic values.

Kern River basin

Four hydroelectric powerplants on the Kern River have an installed capacity of 65 MW. In downstream order they are: Kern No. 3 just above Isabella reservoir, Borel plant about 5 miles below Isabella reservoir, Kern No. 1 about 2 miles above the mouth of the canyon, and Kern Canyon powerplant at the mouth. The three upper plants are the property of the Southern California Edison Company, and the downstream plant is owned by the Pacific Gas and Electric Company. All are run-of-the-river projects and all were constructed prior to 1922.

The lower river has only 360 feet of undeveloped head, located between Borel plant and the diversion for Kern No. 1 plant. In addition to this undeveloped head below Borel plant, there are several potential sites above Isabella reservoir. As this reservoir provides for reregulation of power releases, prospects are favorable for further upstream development at several sites if the formidable water-rights problem can be solved.

Lahontan Area

With the exception of one small plant on the Truckee River, hydroelectric power generation in the Lahontan Area is limited to the nearly complete development of Bishop Creek and tributaries of Mono Lake by the Southern California Edison Company and to plants of the Los Angeles Department of Water and Power on the Owens River and the Los Angeles Aqueduct. Los Angeles authorities realized by 1900 that the city would soon have to supplement locally available water supplies. The Owens River, draining an enclosed basin along the eastern slope of the Sierra Nevada, was selected as the source. The first aqueduct conveying Owens River water to Los Angeles was completed in 1913 and an extension of the aqueduct into the Mono basin was completed in 1941. Along the 338 miles of aqueduct there are 12 hydroelectric powerplants, with a total installed capacity of 234.7 MW.

Colorado Desert Area

The major power development on the Colorado River in the reach where it forms the California-Arizona boundary is at the U. S. Bureau of Reclamation's Parker Dam. The 120 MW of installed capacity is credited to California as the powerhouse is located at the California end of the dam. However, the narrow and extremely arid strip of southeastern California which drains to the Colorado River contributes little to its flow. About 90 percent of the potential power available at drops along the All American Canal has been developed by the Imperial Irrigation District at four plants and by the U. S. Bureau of Reclamation at the Siphon Drop plant. Two undeveloped sites on the canal present the only potential for additional development.

Waterpower in the Future

The continuing steady growth in the use of electric energy will require exploitation of all practicable sources of power to provide the energy to meet future demands. The technological advances in the production of electrical energy in steampower plants, including those using atomic energy, at times have appeared to reduce the value and significance of waterpower. Forecasters, however, predict continued progress in the utilization of waterpower. Such progress can be anticipated in California, particularly in connection with the development of multipurpose projects for irrigation, water supply, water control, and related uses, or the extension of integrated power systems.

Further development of hydroelectric power in California will be related closely to the availability of good powersites. Only half of the potential sites and about half of the gross theoretical power in the State have been developed. Many desirable sites have not been utilized, particularly in the North Coastal Area, where the need for power has been limited and some restrictions on development have been imposed through legislation.

Waterpower, because it is a renewable resource and makes nonconsumptive use of water, will continue to offer significant advantages. Hydropower plants can respond quickly and efficiently to fluctuations in power demand and thus hydropower is used extensively to meet peak-load requirements. This flexibility makes it an ideal partner for the base-load steampower plant, and presumably for those using atomic-energy sources. This is true especially when seasonal storage is available. Although initial costs are high, the rugged hydroelectric installations offer long physical life, low operating costs, and a high degree of reliability.

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Harding, S. T., 1960, Water in California.

Table 3.--Developed waterpower sites

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	′	Longitude °	′	Gross head (feet)	Gross theoretical power with gross head, 100 per-cent efficiency, flows at Q95 (MW)	Q50 (MW)	Qmean (MW)	Installed capacity (MW)	Foot-note
North Coastal Area											
11-A Klamath & Smith River Basins											
Klamath	Copco 1	41	59	122	20	125	3.7	16.7	18.9	20.0	
Fall Creek	Fall Creek	41	59	122	22	730	1.7	2.0	2.2	2.2	
Klamath	Copco 2	41	58	122	22	157	4.6	21.0	23.7	27.0	
Klamath	Iron Gate	41	56	122	26	158	5.0	22.8	25.9	18.0	
Trinity	Trinity	40	47	122	45	485	4.0	29.8	67.1	100.0	
Trinity	Lewiston	40	44	122	48	50	0.6	0.6	0.6	0.3	
Trinity	Salyer	40	53	123	35	650	0.8	0.8	0.8	1.6	
Canyon Creek	Junction City	40	45	123	04	660	0.4	3.9	5.4	2.7	
11-B Russian River Basin											
E. Fk. Russian	Potter Valley	39	22	123	07	477	0.9	4.1	7.7	9.0	
Potential at developed sites		(9)					21.7	101.7	152.3	180.8	

Table 3.--Developed waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Installed capacity MW	Footnotes
South Coastal Area											
11-G Los Angeles Aqueduct											
L. A. Aqueduct	San Francisquito 1	34	35	118	27	935	18.3	32.9	36.6	58.1	a
L. A. Aqueduct	San Francisquito 2	34	32	118	33	540	10.6	19.0	21.1	42.0	a
L. A. Aqueduct	San Fernando	34	18	118	29	253	3.5	6.4	7.1	5.7	a
L. A. Aqueduct	Franklin Canyon	34	06	118	25	285	0.7	1.2	1.3	2.0	a
11-G South Coast River Basins											
San Gorgonio	San Gorgonio 1	34	02	116	52	1773	0.3	0.6	0.9	1.5	
San Gorgonio	San Gorgonio 2	34	01	116	54	898	0.2	0.3	0.5	0.8	
San Luis Rey	Rincon Power	33	15	116	57	824	0.0	0.0	0.1	0.2	
Escondido Creek	Bear Valley	33	10	117	01	400	0.0	0.3	0.8	0.5	
Santa Ana	Santa Ana 1	34	08	117	03	726	1.5	3.5	4.9	3.2	
Santa Ana	Santa Ana 2	34	07	117	04	310	0.7	1.5	2.1	0.8	
Santa Ana	Santa Ana 3	34	06	117	06	348	0.7	1.7	2.4	1.2	
Mill Creek	Mill Creek 3	34	05	117	02	1915	1.3	2.6	3.3	1.8	
Mill Creek	Mill Creek 2	34	05	117	02	627	0.2	0.3	0.5	0.2	
Mill Creek	Mill Creek 1	34	04	117	04	510	0.5	0.9	1.4	0.8	
Lytle Creek	Lytle Creek	34	12	117	26	483	0.5	1.1	1.1	0.4	
Lytle Creek	Fontana	34	09	117	23	658	0.6	1.6	2.0	1.9	
San Antonio Cr.	Ontario 2	34	13	117	40	290	0.1	0.3	0.3	0.3	
San Antonio Cr.	Sierra	34	13	117	41	628	0.2	0.7	0.7	0.5	
San Antonio Cr.	Ontario 1	34	11	117	41	700	0.2	0.8	0.8	0.6	
San Gabriel	Azusa	34	09	117	54	401	0.4	1.2	5.1	3.0	
Potential at developed sites		(28)					40.5	76.9	93.0	125.5	

a. Arbitrary estimates for Q95 and Q50 for complex regulations.

Table 3.--Developed waterpower sites-continued

ydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	Latitude '	Longitude °	Longitude '	Gross head feet	Gross theoretical power with gross head, 100 per-cent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Installed capacity MW	Foot-note
entral Valley Area											
11-B Upper Sacramento River Basin											
Pit	Pit 1	40	59	121	30	454	43.2	52.1	52.1	56.0	
Hat Creek	Hat Creek 1	40	56	121	32	217	8.5	8.9	9.8	10.0	
Hat Creek	Hat Creek 2	40	58	121	32	198	7.7	8.1	8.9	10.0	
Pit	Pit 3	41	00	121	45	315	37.5	54.7	64.9	74.8	
Pit	Pit 4	40	59	121	51	382	47.4	73.1	88.5	90.0	
Pit	McCloud-Pit	40	59	121	59	1226	66.3	101.6	107.3	155.0	
Pit	Pit 5	40	59	121	59	615	74.2	114.5	142.9	128.0	
Pit	Pit 6	40	55	122	00	155	31.4	48.0	56.5	74.0	
Pit	Pit 7	40	51	122	00	206	46.5	71.5	83.7	104.4	
Sacramento	Shasta	40	43	122	25	478	118.8	253.5	338.8	379.0	
Clear Creek	J. F. Carr	40	40	122	38	682	87.6	87.6	87.6	134.0	
Spring Creek	Spring Creek	40	38	122	28	633	82.2	88.1	100.2	150.0	
Sacramento	Keswick	40	37	122	27	101	38.2	66.8	84.8	75.0	
Old Cow Creek	Kilarc	40	41	121	52	1219	0.2	1.8	4.7	3.0	
South Cow Creek	Cow Creek	40	34	122	01	715	0.2	2.3	6.0	1.4	
Battle Creek	Volta	40	28	121	52	1254	4.9	9.5	13.2	6.4	
Battle Creek	South	40	24	121	53	516	5.6	10.7	14.9	4.0	
Battle Creek	Inskip	40	24	121	58	378	4.4	8.4	11.7	6.0	
Battle Creek	Coleman	40	24	122	07	482	6.3	12.2	17.0	13.8	
Butte Creek	New DeSabla	39	52	121	36	1532	7.8	15.6	26.0	18.5	
Butte Creek	Centerville	39	47	121	39	577	3.4	6.9	12.3	6.4	
11-C Feather River Basin											
So. Fk. Feather	Woodleaf	39	33	121	12	1494	2.8	15.6	49.3	52.2	
So. Fk. Feather	Forbestown	39	33	121	17	823	1.7	9.4	29.2	28.8	
So. Fk. Feather	Kelley Ridge	39	32	121	29	668	1.7	8.9	27.1	9.9	

Table 3.--Developed waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Installed capacity MW	Footnote
Central Valley Area (Continued)											
11-C Feather River Basin (Continued)											
Hamilton Branch	Hamilton Branch	40	16	121	05	533	1.8	5.1	9.1	5.4	
Butt Creek	Butt Valley	40	10	121	11	357	16.7	24.3	27.6	36.0	
No. Fk. Feather	Caribou 1	40	05	121	09	1150	18.6	27.4	32.3	75.0	
No. Fk. Feather	Caribou 2	40	05	121	09	1150	37.1	55.7	65.1	109.8	
Rock Creek	Rock Creek	39	54	121	21	535	31.8	66.5	99.7	113.4	
No. Fk. Feather	Bucks Creek	39	55	121	20	2558	1.1	9.8	54.4	66.0	
No. Fk. Feather	Cresta	39	49	121	25	290	18.6	42.3	65.3	67.5	
No. Fk. Feather	Poe	39	43	121	29	477	31.9	74.7	112.6	124.2	
W. Br. Feather	Lime Saddle	39	42	121	34	478	1.0	1.8	2.0	1.6	
W. Br. Feather	Coal Canyon	39	37	121	36	545	1.2	2.1	2.3	0.8	
Feather	Oroville	39	32	121	29	675	65.1	147.1	310.1	644.2	
Feather	Thermalito	39	31	121	38	90	5.6	16.6	38.5	115.1	
No. Fk. Yuba	Bullards Bar	39	25	121	08	166	2.3	10.7	21.8	6.5	
No. Fk. Yuba	Colgate	39	20	121	11	820	11.2	35.5	35.5	24.0	
So. Fk. Yuba	Spaulding 3	39	20	120	38	318	0.5	3.2	7.3	6.3	
So. Fk. Yuba	Spaulding 1	38	20	120	38	197	0.7	3.2	9.1	6.4	
So. Fk. Yuba	Spaulding 2	38	20	120	38	344	0.6	1.8	2.4	3.7	
Yuba	Narrows	39	14	121	16	240	4.7	11.8	11.8	9.4	
So. Fk. Deer Cr.	Deer Creek	39	18	120	50	1048	1.8	5.3	7.3	5.5	
Bear	Drum 1	39	15	120	46	1439	2.8	12.5	35.8	48.0	
Bear	Drum 2	39	15	120	46	1439	2.6	11.5	33.0	44.1	
Little Bear	Alta	39	13	120	48	904	0.8	1.4	1.5	2.0	
Bear	Dutch Flat 1	39	13	120	50	643	1.1	5.5	16.4	22.0	
Bear	Dutch Flat 2	39	13	120	50	643	1.3	5.5	15.9	23.4	
Bear	Chicago Park	39	11	120	53	505	1.9	8.7	25.8	37.4	
Dry Creek	Halsey	38	57	121	03	331	1.1	5.1	9.7	12.0	

Table 3.--Developed waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Installed capacity	Footnotes
Central Valley Area (Continued)											
11-C Feather River Basin (Continued)											
Auburn Ravine	Wise	38	53	121	06	519	1.3	7.1	14.1	12.0	
11-D Lower Sacramento River Basin											
Rubicon	French Meadows	39	04	120	25	619	0.1	2.9	10.0	15.3	
Mid. Fk. American	Middle Fork	39	02	120	36	2110	0.5	23.1	80.5	109.8	
Rubicon	Ralston	39	00	120	44	1342	0.5	16.5	57.3	79.2	
Mid. Fk. American	American Bar	38	59	120	50	282	1.0	7.5	24.7	6.0	
Silver Creek	Robbs Peak	38	53	120	23	356	0.2	2.0	6.0	25.0	
So. Fk. American	El Dorado	38	48	120	37	1910	9.7	20.3	22.7	20.0	
Silver Creek	Union Valley	38	52	120	26	420	0.4	5.4	17.3	33.3	
Silver Creek	Jaybird	38	50	120	32	1540	1.4	22.6	71.1	133.0	
Silver Creek	Camino	38	48	120	37	1050	1.1	16.9	52.7	142.5	
So. Fk. American	White Rock	38	46	120	46	860	6.8	30.3	84.7	200.0	
So. Fk. American	Chili Bar	38	46	120	49	60	0.5	2.2	6.5	7.0	
American	Folsom	38	42	121	10	340	4.2	43.4	108.3	162.0	
American	Nimbus	38	38	121	13	42	0.5	5.3	13.2	13.5	
11-F San Joaquin River Basin											
Kern	Kern 3	35	46	118	26	821	9.4	22.9	49.4	32.0	
Kern	Borel	35	35	118	31	270	3.3	10.4	21.2	9.2	
Kern	Kern 1	35	28	118	47	877	11.2	35.0	71.3	16.0	
Kern	Kern Canyon	35	26	118	47	262	3.3	10.5	21.3	8.5	
Middle Fork Tule	Tule	36	10	118	42	1563	1.7	4.0	7.6	4.8	
Tule	Tule	36	07	118	47	1151	1.8	3.9	7.6	2.0	
Mid. Fk. Kaweah	Kaweah 3	36	29	118	50	804	1.2	9.0	17.4	2.8	
Kaweah	Kaweah 1	36	28	118	51	1482	1.3	9.7	18.1	2.3	
Kaweah	Kaweah 2	36	27	118	52	389	0.6	4.5	8.6	1.8	

Table 3.--Developed waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power with gross head, 100 percent efficiency, flows at: Q95 MW	Q50 MW	Qmean MW	Installed capacity	Footnotes
Central Valley Area (Continued)											
[illegible]- San Joaquin River Basin											
North Fork Kings	Haas	36	55	119	01	2444	1.0	12.5	74.2	135.0	
North Fork Kings	Balch 1	36	55	119	05	2279	0.4	5.3	30.9	31.0	
North Fork Kings	Balch 2	36	55	119	05	2389	1.0	10.6	62.3	97.2	
Kings	Kings	36	53	119	10	750	0.8	7.7	40.9	44.1	
San Joaquin	Mammoth Pool	37	13	119	20	1100	13.4	59.8	124.4	129.4	
Big Creek	Portal	37	15	119	10	230	0.9	4.5	9.0	10.0	
Big Creek	Big Creek 1	37	13	119	15	2131	20.8	67.0	90.6	67.0	
Big Creek	Big Creek 2	37	12	119	18	1858	18.2	58.4	79.0	57.8	
Big Creek	Big Creek 2A	37	12	119	18	2418	11.5	37.0	45.2	80.0	
San Joaquin	Big Creek 8	37	12	119	20	723	10.3	33.3	44.8	58.5	
San Joaquin	Big Creek 3	37	08	119	23	827	21.1	85.1	145.5	106.5	
San Joaquin	Big Creek 4	37	07	119	29	416	11.7	46.0	76.0	84.0	
No. Fk. Willow Cr.	Crane Valley	37	17	119	31	120	0.0	0.3	0.7	0.8	
No. Fk. Willow Cr.	San Joaquin 3	37	15	119	31	438	0.0	0.9	2.5	4.0	
Willow Creek	San Joaquin 2	37	12	119	30	345	0.0	0.7	2.0	2.4	
Willow Creek	San Joaquin 1A	37	09	119	30	72	0.0	0.2	0.7	0.3	
Willow Creek	A. G. Wishon	37	08	119	30	1412	0.4	3.6	13.2	12.8	
San Joaquin	Kerckhoff	37	05	119	34	350	10.7	49.1	68.1	34.1	
Merced	Yosemite	37	43	119	43	330	0.6	4.5	17.6	2.0	
Merced	Exchequer	37	35	120	16	462	1.5	33.4	52.6	80.1	
Merced	McSwain	37	31	120	18	61	0.2	4.4	7.0	9.0	
Merced	Merced Falls	37	31	120	20	27	0.1	2.0	3.1	3.4	
Tuolumne	Canyon	37	53	119	57	1452	4.7	86.4	124.2	67.5	
Cherry Creek	Cherry Creek	37	54	119	58	2484	0.4	48.1	123.9	150.0	
Hetch-Hetchy Aq.	Moccasin Creek	37	49	120	18	1316	33.6	69.4	81.7	70.0	

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Installed capacity MW	Footnotes
Central Valley Area (Continued)											
11-F San Joaquin River Basin											
Tuolumne	Don Pedro	37	43	120	24	264	[illegible].2	19.1	43.5	27.0	
Tuo[illegible]	La Grange	37	40	120	26	[illegible]	[illegible]	1.9	5.6	3.9	
[illegible] Stanislaus	Donnells	38	15	120	02	146[illegible]	[illegible]	28.0	65.6	54.0	
[illegible] Stanislaus	Beardsley	38	12	120	04	264	[illegible]	6.2	14.7	10.0	
Mid Fk.Stanislaus	Spring Gap	38	11	120	07	193[illegible]	[illegible].0	3.6	7.1	6.0	
Stanislaus	Stanislaus	38	08	120	23	1685	12.0	43.0	99.8	81.9	
Utica Ditch	Murphys	38	09	120	26	685	[illegible]	3.5	4.7	3.6	
Utica Ditch	Angels	38	05	120	32	448	0.8	1.1	1.5	1.4	
Sullivan Creek	Phoenix	38	02	120	20	1155	1.2	2.0	2.4	1.6	
Stanislaus	Melones	37	57	120	32	230	0.8	8.8	29.5	24.3	
Stanislaus	Tulloch	37	52	120	36	157	0.5	9.3	20.1	17.1	
No. Fk. Mokelumne	Salt Springs 2	38	30	120	13	2109	0.9	8.2	23.3	29.7	
No. Fk. Mokelumne	Salt Springs 1	38	30	120	13	256	[illegible].7	6.6	10.0	9.4	
No. Fk. Mokelumne	Tiger Creek	38	27	120	30	121[illegible]	[illegible]	36.3	59.8	51.0	
No. Fk. Mokelumne	West Point	38	25	120	33	312	[illegible]	9.5	16.2	13.6	
Mokelumne	New Electra	38	20	120	40	1268	9.7	38.8	65.7	89.1	
Mokelumne	Pardee	38	15	120	51	327	1.9	14.7	23.3	15.0	
Potential at developed sites		(115)					1277.6	3011.1	5094.2	6013.8	

drographic Area / Sub-Basin / River	Site	Powerhouse location: Latitude ° '	Powerhouse location: Longitude ° '	Gross head feet	Gross theoretical power with gross head, 100 per-cent efficiency, flows at: Q95 MW	Q50 MW	Qmean MW	Installed capacity MW	Foot-notes
hontan Area									
10-B Pyramid Lake Basin									
Truckee	Farad	39 25	120 02	90	0.7	2.0	6.1	2.8	
10-E Walker-Mono Lake Basins									
Mill Creek	Mill Creek - Out of service.								
Lee Vining Creek	Poole	37 57	119 13	1689	1.7	5.0	9.6	10.0	
Rush Creek	Rush Creek	37 46	119 08	1807) 1249)	1.2	3.1	6.1	8.4	
10-G Owens Lake Basin									
Milner Creek	White Mountain	37 37	118 23	2005	0.2	0.3	0.5	0.3	
Owens	Upper Gorge	37 33	118 35	802	11.2	20.5	22.5	37.5	a
Owens	Middle Gorge	37 30	118 34	795	11.1	20.3	22.3	37.5	a
Owens	Control Gorge	37 26	118 34	780	10.9	19.9	21.9	37.5	a
Owens	Pleasant Valley	37 25	118 31	87	1.3	2.3	2.6	3.2	a
Bishop Creek	Bishop Creek 2	37 16	118 35	953	1.1	2.8	5.7	7.3	
Bishop Creek	Bishop Creek 3	37 18	118 32	809	1.0	2.4	4.8	6.6	
Bishop Creek	Bishop Creek 4	37 19	118 30	1112	1.3	3.3	6.6	6.8	
Bishop Creek	Bishop Creek 5	37 20	118 29	415	0.5	1.2	2.5	3.5	
Bishop Creek	Bishop Creek 6	37 21	118 28	260	0.3	0.8	1.5	1.6	
Big Pine Creek	Big Pine Creek 3	37 08	118 19	1245	0.6	1.7	3.4	3.2	
Division Creek	Division Creek	36 56	118 16	1250	0.2	0.3	0.5	0.6	
Cottonwood Creek	Cottonwood	36 27	118 02	1377	0.5	2.2	4.4	1.5	
L. A. Aqueduct	Haiwee	36 06	117 57	193	4.3	7.7	8.5	5.6	a
Potential at developed sites		(17)			48.1	95.8	129.7	173.9	

a. Arbitrary estimates for Q95 and Q50 for complex regulations.

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude ° '		Longitude ° '		Gross head feet	Gross theoretical power with gross head, 100 percent efficiency, flows at: Q95 MW	Q50 MW	Qmean MW	Installed capacity	Footnote
Colorado Desert Area											
9-1 Lower Colorado River Basin											
Colorado	Parker	34	18	114	08	78	38.1	90.2	90.9	120.0	b
All-American Canal	Siphon Drop	32	47	114	38	15	2.0	2.2	2.2	1.6	a
All-American Canal	Pilot Knob	32	44	114	43	55	0.0	4.7	7.0	33.0	a
All-American Canal	Drop 2	32	42	115	02	25	4.0	7.2	8.0	10.0	a
All-American Canal	Drop 3	32	42	115	08	25	3.6	6.6	7.4	9.8	a
All-American Canal	Drop 4	32	42	115	13	51	6.9	13.0	14.3	19.6	a
Potential at developed sites		(6)					54.6	123.9	129.8	194.0	

a. Arbitrary estimates for Q95 and Q50 for complex regulations.

b. Entire installed capacity located in and credited to California.

Table [illegible].--Undeveloped waterpower [illegible]

[illegible] Area / Sub-basin / [illegible]	Site	Powerhouse location: Latitude °	'	Longitude °	'	[illegible] head [illegible]	Gross theoretical power, with gross head, 100 percent efficiency, flows at: Q95 MW	Q50 MW	Qmean MW	Footnotes
[illegible] Area										
[illegible] & Smith River Basins										
[illegible] Fk. Smith	Peridotite	41	54	[illegible]	[illegible]	[illegible]	[illegible]	17.3	36.7	
[illegible] Fk. Smith	Big Flat	41	41	123	53	[illegible]	2.3	17.0	36.0	
[illegible]	Junction	41	47	124	03	[illegible]	8.1	63.6	134.5	
[illegible]	Junction Afterbay	41	46	124	04	[illegible]	0.4	2.9	6.2	
Klamath	Warm Springs	41	58	122	15	[illegible]	4.5	20.4	23.2	
Klamath	Badger Creek	41	50	122	37	[illegible]	9.2	41.8	47.6	
Scott	Callahan	41	19	122	48	[illegible]	0.6	3.3	6.5	
Scott	Scott Valley	41	42	123	01	755	2.2	16.7	36.6	
Klamath	Hamburg	41	47	123	03	390	41.4	103.8	133.9	
Klamath	Happy Camp	41	44	123	24	[illegible]	77.0	192.3	248.5	
No. Fk. Salmon	Sawyer Bar	41	48	123	09	700	1.8	8.9	17.3	
No. Fk. Salmon	Heiney Bar	41	17	123	15	500	1.7	6.8	13.2	
So. Fk. Salmon	Black Bear	41	11	123	13	800	1.9	14.1	23.0	
Salmon	Morehouse	41	19	123	23	530	4.8	35.9	58.1	
Klamath	Slate Creek	41	15	123	39	740	112.9	325.8	506.2	
Stuart Fork	Stuart Fork 1	40	57	122	57	600	0.9	2.7	3.2	
Stuart Fork	Stuart Fork 2	40	53	122	56	950	1.5	4.5	5.0	
Stuart Fork	Stuart Fork 3	40	51	122	52	513	2.0	5.7	6.2	
No. Fk. Trinity	Noonan Gulch	40	51	123	08	1348	1.7	16.0	24.1	
Trinity	Helena	40	45	123	10	632	10.2	32.9	56.8	
Trinity	Burnt Ranch	40	48	123	28	270	4.8	17.3	31.3	
So. Fk. Trinity	Smokey Creek	40	19	123	15	320	0.4	3.7	8.7	
So. Fk. Trinity	Forest Glen	40	28	123	25	860	1.7	15.0	35.1	
Hayfork Creek	Hayfork	40	34	123	14	680	0.8	4.9	18.5	
South Fork	Eltapom	40	43	123	31	670	2.8	22.1	74.9	

Table 4.--Undeveloped waterpower sites--continued

Hydrographic Area / Subbasin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power with gross head, 100 per-cent efficiency, flows at: Q95 MW	Q50 MW	Qmean MW	Foot-notes
North Coastal Area (Continued)										
1-A Klamath & Smith River Basins (Continued)										
New	Denny	40	52	123	27	650	0.9	8.8	19.9	
Trinity	Beaver	41	07	123	41	690	21.6	115.1	246.8	
Klamath	Humboldt	41	27	123	56	220	47.2	183.3	295.0	
1-B North Coast River Basins										
E. Fk. Russian	Lake Mendocino	39	12	123	11	155	1.3	3.6	4.3	
Mattole	Point Delgada	40	03	124	04	1030	0.4	4.4	15.9	
Eel	Scott	39	24	122	58	150	0.4	2.6	6.5	
Eel	Willis Ridge	39	37	123	20	450	0.2	5.3	45.4	
Mid. Fk. Eel	Etsel	39	46	123	09	420	0.4	12.7	32.8	
Mid. Fk. Eel	Salt Creek	39	42	123	15	250	0.3	13.2	34.2	
Eel	Bell Springs	39	54	123	28	345	0.9	26.2	101.8	
Casoose Creek	Casoose Creek	40	01	123	12	1230	0.6	11.5	28.0	
Hull Creek	Hull Creek	40	00	123	16	1380	0.9	15.2	36.4	
So. Fk. Eel	Red Mountain	40	01	123	16	630	0.1	2.7	15.5	
So. Fk. Eel	Mina 1	39	56	123	23	345	0.3	7.2	27.8	
So. Fk. Eel	Mina 2	39	57	123	26	365	0.3	7.6	29.5	
Eel	Island Mtn.	40	02	123	30	150	0.5	14.5	56.4	
Eel	Sequoia	40	18	123	46	260	0.8	28.4	122.9	
No. Fk. Eel	Branscomb	39	50	123	39	610	0.3	3.0	13.5	
Eel	Dyerville	40	22	123	55	45	0.2	5.0	25.5	
Van Duzen	Bridgeville	40	28	123	47	1900	0.3	7.3	32.3	h

h. Partial Van Duzen River diversion to Mad River included.

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
North Coastal Area (Continued)										
11-E North Coast River Basins (Continued)										
Yager Creek	Yager Creek	40	32	124	02	370	0.2	1.9	10.6	
Mad	Ruth	40	22	123	26	220	0.1	1.1	6.6	
Mad	Dinsmore Tunnel	40	28	123	31	360	0.3	4.0	20.6	h
Mad	Coyote	40	36	123	40	250	0.3	3.5	19.2	h
Mad	Big Bend	40	40	123	50	1193	1.2	17.9	95.9	h
Mad	Gold Rock	40	44	123	52	307	0.3	5.0	26.3	h
Mad	Butler Valley	40	46	123	53	95	0.1	1.7	8.9	h
Mad	Sweasey	40	49	123	58	155	0.2	3.0	15.8	h
Little	Little River	41	02	123	59	450	0.5	5.2	19.2	
Little	Crannell	41	01	124	04	250	0.4	3.6	13.8	
Potential at undeveloped sites		(55)					379.3	1519.9	3018.6	

h. Partial Van Duzen River diversion to Mad River included.

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at: Q95 MW	Q50 MW	Qmean MW	Footnotes
South Coastal Area										
11-G South Coast River Basins										
Bear Creek	Bear Creek 1	34	13	117	00	1220	1.7	2.6	5.2	
Santa Ana	Bear Creek 2	34	10	116	56	1200	1.6	2.6	5.1	
Santa Ana	Bear Creek 3	34	10	117	01	620	1.1	2.6	3.7	
Mill Creek	Forest Home	34	05	116	56	2080	0.9	1.6	2.1	
Potential at undeveloped sites		(4)					5.3	9.4	16.1	

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head Feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
Central Valley Area										
11-B Upper Sacramento River Basin										
Sacramento	Wagon Creek	41	11	121	16	1060	2.3	7.5	18.5	
Pit	Big Valley	41	01	121	15	840	0.0	8.8	37.3	
Pit	Pit 2	42	00	121	34	112	11.2	14.4	17.2	
Hat Creek	Sugar Loaf	40	44	121	26	700	4.6	6.0	7.1	
McCloud	Upper Falls	41	14	122	02	410	4.7	6.4	8.7	
McCloud	Big Springs	41	11	122	04	360	14.3	21.1	22.5	
Clear Creek	Towerhouse	40	40	122	38	400	0.5	4.2	11.9	
Clear Creek	Whiskeytown	40	36	122	32	278	0.4	3.1	8.5	d
Mid.Fk. Cottonwood Cr.	Fiddlers	40	20	122	39	300	0.5	2.4	7.9	
Sacramento	Cottonwood	40	24	122	15	80	28.6	53.9	68.1	d
Sacramento	Iron Canyon	40	14	122	10	140	45.2	103.2	154.2	d
Deer Creek	Deer Creek 1	40	09	121	39	2025	10.3	18.2	30.5	
Deer Creek	Deer Creek 2	40	04	121	49	920	7.3	15.2	27.6	
Deer Creek	Deer Creek 3	40	01	121	54	1050	8.3	17.3	31.5	
Deer Creek	Deer Creek 4	39	59	121	57	270	2.6	5.6	10.7	
11-C Feather River Basin										
Mid. Fk. Feather	Meadow Valley	39	47	121	09	1519	7.7	31.0	89.1	
Mid. Fk. Feather	Swayne	39	42	121	25	1430	13.4	54.7	151.9	
Mid. Fk. Feather	Bald Rock 5	39	38	121	16	710	1.1	6.6	18.1	
So. Fk. Feather	L. Grass Valley	39	39	121	07	1489	0.3	2.0	12.7	
So. Fk. Feather	Sly Creek	39	35	121	07	248	0.4	2.5	8.1	

d. Assumes Trinity River not diverted to Sacramento Basin.

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location Latitude ° '		Longitude ° '		Gross head feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
Central Valley Area (Continued)										
11-C Feather River Basin (Continued)										
Last Chance Creek	Squaw Queen	40	03	120	40	1680	0.3	4.9	20.3	
Indian Creek	Genesee	40	03	120	48	190	0.1	1.5	6.1	
Indian Creek	Indian Falls	40	02	121	01	490	0.2	5.4	22.4	
E. Br. No.Fk. Feather	Belden 2	40	01	121	15	770	1.1	12.1	46.9	
E. Br. No.Fk. Feather	Belden	40	01	121	15	770	37.8	57.3	68.5	
Yellow Creek	Yellow Creek	40	01	121	15	2152	2.7	7.5	12.8	
Grizzly Creek	Grizzly Creek	39	53	121	17	688	0.2	2.3	12.9	
No. Fk. Yuba	Goodyears Bar	39	33	120	52	1530	4.2	11.7	28.6	
No. Fk. Yuba	Indian Valley	39	31	121	01	430	5.0	13.6	33.1	
No. Fk. Yuba	Wambo	39	31	121	06	275	2.9	13.7	27.4	
No. Fk. Yuba	New Bullards Bar	39	23	121	08	605	7.1	33.8	72.8	g
No. Fk. Yuba	New Colgate	39	20	121	11	820	1.6	24.8	92.7	
So. Fk. Yuba	Lake Valley	39	19	120	37	838	0.9	3.6	10.8	
Yuba	New Narrows	39	14	121	16	242	0.0	9.0	36.3	
Bear	Rollins	39	08	120	57	240	0.2	1.2	7.9	
11-D Lower Sacramento River Basin										
No. Fk. American	Giant Gap	39	13	120	26	1136	3.1	12.6	51.2	
So. Fk. Rubicon	Loon Lake	38	58	120	23	1180	0.2	3.2	9.9	
No. Fk. American	Auburn	38	52	121	03	662	4.8	38.6	113.3	
So. Fk. American	Kyburz	38	46	120	19	2320	3.7	10.5	24.8	
So. Fk. American	Van Winkle	38	42	120	12	1600	1.2	4.6	9.5	

g. Additional potential when existing plant replaced.

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
Central Valley Area (Continued)										
11-D Lower Sacramento River Basin (Continued)										
So. Fk. American	Alder Creek	38	45	120	22	1465	2.5	9.3	21.0	
Silver Creek	Jones Fork	38	51	120	23	580	0.0	1.0	3.6	
So. Fk. American	Salmon Falls	38	46	121	01	474	3.6	17.3	53.6	
Cache Creek	Wilson Valley	38	57	122	27	370	0.0	1.3	18.2	
11-F San Joaquin River Basin										
Kern	Little Kern	36	08	118	27	1020	17.3	36.4	42.5	
Kern	Junction	35	59	118	29	1120	19.0	51.4	60.0	
So. Fk. Kern	Rockhouse	35	49	118	12	940	0.4	2.7	7.6	
So. Fk. Kern	Onyx	35	45	118	12	1630	0.7	5.3	14.7	
Kern	Kern 2	35	31	118	40	330	4.1	12.7	25.9	
Kern	Ant Hill	35	27	118	53	174	2.2	7.0	14.1	
E. Fk. Kaweah	East Fork	36	27	118	47	580	0.5	3.7	6.9	
Kaweah	Terminus	36	25	119	00	174	0.5	3.0	8.3	
So. Fk. Kings	Cedar Grove	36	50	118	52	2070	9.1	36.9	103.6	
Mid. Fk. Kings	Tehipite	36	51	118	52	1710	7.1	24.1	65.6	
Kings	Hume	36	51	118	55	3180	1.1	3.8	10.5	
Kings	Junction	36	52	119	00	950	11.1	37.1	102.1	
Kings	Kellers Ranch	36	53	119	08	450	5.6	18.8	51.5	
No. Fk. Kings	Helms	37	03	118	57	1638	0.6	3.3	27.8	
Dinkey Creek	Ross	36	59	119	07	1100	0.4	3.4	13.0	
Dinkey Creek	Dinkey Creek	36	55	119	05	2530	1.1	8.6	34.4	
Kings	Pine Flat	36	50	119	20	388	5.3	29.7	72.6	
San Joaquin	Miller Bridge	37	28	119	14	840	2.9	12.1	37.1	
San Joaquin	Forks	37	24	119	16	620	2.7	13.0	37.4	

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude °	'	Longitude °	'	Gross head Feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
Central Valley Area (Continued)										
11-F San Joaquin River Basin (Continued)										
Chiquito Creek	Jackass	37	27	119	24	2090	2.1	9.4	32.9	
San Joaquin	Chiquito	37	24	119	16	1650	3.1	14.4	41.4	
San Joaquin	Friant	36	59	119	43	268	1.4	6.8	14.8	
Fresno	Windy Gap	37	19	119	49	1180	0.0	2.1	6.0	
So. Fk. Merced	Hite Cove	37	38	119	50	1000	1.2	7.9	31.5	
So. Fk. Merced	Sweetwater	37	39	119	55	300	0.4	2.9	10.5	
Merced	Bagby	37	37	120	09	400	1.3	14.8	40.0	
So. Fk. Tuolumne	South Fork	37	49	120	00	1300	0.4	2.8	13.5	
Tuolumne	Big Humbug Creek	37	53	120	13	1780	0.8	7.4	25.9	
Clavey	Upper Clavey	37	59	120	03	1800	0.5	8.0	21.4	
Clavey	Ingalls	37	56	120	13	1700	0.3	9.4	24.6	
No. Fk. Tuolumne	Paper Cabin	37	54	120	24	700	0.2	6.5	13.7	
Tuolumne	New Don Pedro	37	43	120	24	530	5.2	19.2	43.8	g
Mid. Fk. Stanislaus	Relief	38	17	119	44	700	0.8	4.0	7.9	
Mid. Fk. Stanislaus	Dardanelles	38	21	119	56	575	2.5	7.2	18.6	
Mid. Fk. Stanislaus	Sand Bar	38	11	120	08	391	2.8	9.2	21.7	
No. Fk. Stanislaus	Highland	38	24	120	04	745	0.6	2.2	9.2	
No. Fk. Stanislaus	Squaw Hollow	38	16	120	16	2225	3.6	12.7	52.6	
No. Fk. Stanislaus	Collierville	38	08	120	23	2470	1.7	15.5	100.1	
Sullivan Creek	Phoenix (Enl.)	38	02	120	20	1180	0.0	0.0	5.6	g
Stanislaus	New Melones	37	57	120	32	578	1.2	13.3	44.5	g
No. Fk. Mokelumne	Stevenot	38	34	120	01	1040	0.8	3.5	15.4	

g. Additional potential when existing plant replaced.

Table 4.--Undeveloped waterpower sites-continued

Hydrographic Area / Sub-basin / River	Site	Powerhouse location: Latitude ° '		Longitude ° '		Gross head feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
Central Valley Area (Continued)										
11-F San Joaquin River Basin (Continued)										
No. Fk. Mokelumne	Summit City	38	30	120	09	1640	1.7	8.1	38.2	
So. Fk. Mokelumne	Railroad Flat	38	22	120	57	1620	0.4	4.5	19.1	
Mokelumne	Middle Bar	38	17	120	46	115	1.0	4.1	9.4	
Mokelumne	Camanche	38	13	121	02	125	0.7	5.6	8.9	
Cosumnes	Nashville	38	33	120	52	465	0.3	7.1	18.4	
Potential at undeveloped sites		(90)					373.8	1206.5	2965.9	

Table 4.--Undeveloped waterpower sites--continued

Hydrographic Area Sub-basin River	Site	Powerhouse location Latitude °	'	 Longitude °	'	Gross head Feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	 Q50 MW	 Qmean MW	Footnotes
Lahontan Area										
10-B Pyramid Lake Basin										
Little Truckee	Independence	39	28	120	13	950	0.6	1.3	2.7	
Little Truckee	Stampede	39	28	120	06	200	0.2	1.0	3.1	
10-C Carson Sink Basin										
W. Fk. Carson	Woodfords	38	46	119	51	1100	1.0	2.5	7.1	
W. Fk. Carson	Paynesville	38	49	119	38	952	1.4	3.2	9.5	
10-E Walker-Mono Lake Basins										
East Walker	Bridgeport	38	25	119	10	500	1.3	2.6	5.6	
West Walker	Leavitt	38	20	119	33	400	0.5	1.7	5.2	
West Walker	Antelope Valley	38	31	119	27	1200	2.7	8.7	25.9	
10-G Owens Lake Basin										
Bishop Creek	Bishop Creek 1	37	15	118	35	900	0.8	2.1	4.2	
Big Pine Creek	Big Pine 1	37	08	118	26	1209	0.6	1.6	3.3	
Big Pine Creek	Big Pine 2	37	07	118	21	1789	0.9	2.4	4.9	
Cottonwood Creek	Powerhouse 1	36	28	118	06	2077	0.7	1.9	3.9	
Cottonwood Creek	Powerhouse 2	36	26	118	05	2166	0.7	2.8	5.5	
Potential at undeveloped sites		(12)					11.4	31.8	80.9	

Table 4.--Undeveloped waterpower sites--continued

Hydrographic Area / Sub-Basin / River	Site	Powerhouse location: Latitude ° '	Powerhouse location: Longitude ° '	Gross head feet	Gross theoretical power, with gross head, 100 percent efficiency, flows at Q95 MW	Q50 MW	Qmean MW	Footnotes
Colorado Desert Area								
9-L Lower Colorado River Basin								
All-American Canal	Drop 1	32 43	114 57	13	2.1	3.8	4.2	a
All-American Canal	Drop 5	32 40	115 23	24	3.1	5.5	6.1	a
Potential at undeveloped sites		(2)			5.2	9.3	10.3	

a. Arbitrary estimates for Q95 and Q50 for complex regulations.